MEMO

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TO: City of Wichita
455 N. Main – 7th Floor
Wichita, KS 67202

ATTENTION: Deb Ary

FROM: Sarah Unruh

REFERENCE: DRAFT Report

DATE: July 29, 2015

PROJECT NO.: 35-15245-000-0042

PROJECT: City of Wichita NW WTP Land Use Study

COPIES TO: Alan King, Ben Nelson, Mike Kelsey

Please advise immediately of any misconceptions or omissions you believe to be contained herein.

Purpose

The City of Wichita acquired property located southeast of 21st Street West and Zoo Boulevard for location of a future water treatment plant (WTP). In preparation for a water treatment plant, the city constructed a 66" raw water line and 36" finished water line with future connection tees on the west side of the property. The city has been approached by an entity interested in purchasing a 10-acre tract in the northwest corner of the property, an area approximately 600' x 700'. The city commissioned this study to determine first if the existing pond area could be filled in for construction of structures, and second to determine the estimated costs for construction of a 60 MGD reverse osmosis WTP on the property.

This study included the following general tasks:

- Geotechnical investigations to determine soil materials at the site, depth to groundwater, and composition of the pond
- Permitting review to establish potential local, state, and federal permits required to construct on the site
- Preliminary layout of structures and yard piping connections for a 60 MGD reverse osmosis WTP on the existing site and with the pond filled in and the 10 acres removed
- Development of 1% planning level cost estimates for each of the two layout options

Geotechnical Investigations

Geotechnical investigations at the site were completed and included soil borings to determine existing groundwater depth and soil profiles, and borings in the existing pond area to determine the depth of the muck and to determine volume required for backfill of the pond area. A total of four soil borings and six pond borings were completed. Groundwater was encountered between 14 and 19.5 feet below the surface across the site, and the muck in the pond ranged in depth from 0 inches to 10 feet. The soils investigation concluded the following:

- Concrete and other debris was encountered in some borings during site exploration; over-excavation may be required for the construction of structures on the site.
- Subsurface conditions are adaptable for the support of shallow foundations; pier foundations are not required to support structures.
- An underdrain system is recommended for below grade structures, based on the nature of the soils and the elevation of ground water.

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The existing pond would need to be dredged to remove the full depth of the muck and filled with engineered fill as specified in the soils report to support structure foundations. Based on survey data and an approximate depth of muck across the pond, a rough estimate of the total fill required to excavate the pond and bring it to grade is approximately 384,000 cubic yards of fill material.

The full geotechnical report is included as Appendix A for reference.

Permitting

Floodplain Permitting

Portions of the project site are located within the recently updated released preliminary flood maps denoted as Zone A. By definition, Zone A is areas subject to inundation by the 1-percent-annual-chance (100-year) flood event. As site development occurs, coordination and permitting will likely be required with the Federal Emergency Management Administration (FEMA). A Letter of Map Amendment (LOMA) will be required to verify that all structures are constructed above the Base Flood Elevation (BFE) and flood insurance will not be required.

In the event that preliminary mapping becomes effective prior to construction, a Conditional Letter of Map Amendment (CLOMA) should be filed with FEMA to ensure that once the project is complete and appropriate as-built information is provided, all structures will be omitted from the floodplain and not required to carry flood insurance. In addition to the CLOMA application, coordination with the Kansas Department of Agriculture Division of Water Resources (DWR) will be required for floodplain fill permitting. DWR will require either compensatory volume be provided for floodplain fill or calculations illustrating no negative impact or rise in the BFE through the permitting process. These items should be taken under consideration during design document development and coordination with the appropriate government agencies should occur prior to construction for a successful outcome.

Development Permitting

The site currently consist of three parcels, but they are not platted. Use of the site for the water treatment plant will require the site to be platted and a conditional use permit obtained since the property zoning currently consists of areas of Limited Commercial (LC) and Single Family (SF-5). The water treatment plant is considered a “Major Utility” and is therefore allowed in each of these zoning areas, but a conditional use permit would be required.

Site Layouts

The city has expressed an interest in constructing a 60 MGD reverse osmosis WTP on this site in the future. To determine if it is feasible to construct the necessary facilities on the site, very preliminary structure sizing, yard piping, access, paving, and fencing were established and located on the site. As indicated above, two site layouts were prepared, one utilizing the full site and one assuming the pond was filled and the 10-acre tract was removed. Figure 1 illustrates a preliminary site layout based on the full 85 acre site being available for use. Figure 2 illustrates a preliminary site layout with the 10 acres tract in the northwest corner of the property removed, and the existing pond filled in for construction.

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Preliminary Structure Sizing

The WTP facilities identified by the city for inclusion in the site plan as phase 1 facilities were as follows:

- 60 MGD reverse osmosis (RO) treatment process
- Chemical storage
- On-site Sodium Hypochlorite generation
- RO reject flow storage and pumping
- 10 MG raw water storage
- 20 MG finished water storage
- Pumps to Hess Pump Station
- Maintenance facility
- Materials storage
- Backup power generator

The structures included on the preliminary site plans for the phase 1 improvements include an administration building, a maintenance facility, an operations building, raw water storage, finished water storage, and RO waste stream storage. Preliminary sizes for these structures were based on equipment research and past project experiences.

The administration building is shown as 60' x 35' to accommodate an office, laboratory, restroom, and mechanical systems. An 80' x 40' maintenance facility is shown for the storage and repair of equipment to be used at the site. An area is identified for a generator to operate the essential facility operations in the event of a loss of power. An operations building is shown with dimensions of 370' x 275' to accommodate filters, RO skid units, raw water pumps, finished water pumps, RO reject flow pumps, chemical feed, disinfection, electrical and HVAC systems, and storage. The 273' x 273' raw and finished water storage basins are based on a below grade depth of 12' and 2' of freeboard depth. The RO reject storage basin is shown as 299' x 299' based on the same conditions as the water storage basins. Typical RO systems have a reject rate of approximately 20%, meaning a total raw water volume of 72 MGD would produce 60 MGD of finished water and 12 MGD of RO reject flow. A reject volume of 12 MGD equates to approximately 8,300 gpm of flow. The basin indicated would hold one day's worth of reject water if the plant is running at full capacity. Also shown is a pump station to send water to the Hess Pump Station at dimensions of 150' x 150'.

This site is also being considered for future facilities in a phase 2 plan that would allow this RO plant to be a backup to the main water treatment plant, and to allow for this facility to treat water from Cheney Reservoir to be sent to the Aquifer Storage and Recovery (ASR) well injection sites. These phase 2 future structures as indicated on the figures include 273' x 273' storage reservoirs for raw water and storage for pumping to the ASR well injection sites. Also shown is a 150'x 150' pump station for pumping water to the ASR well injection sites, and a storage facility to accommodate the city's supply of 6"-66" diameter pipe for maintenance and replacement projects.

Preliminary Yard Piping

Since the treatment processes all take place within the operations building, the preliminary piping shown includes raw water supply, water piping to and from the operations building, and finished water piping to the distribution system for the phase 1 improvements.

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Preliminary Easements
The site is currently fully owned by the City of Wichita and easements exist for the raw water, finished water, and sanitary sewer lines on the property. Connection to these lines will not require additional easements if the city retains ownership of the entire property. If the city releases the 10-acre tract in question, acquisition of easements for piping and site access should be considered.

Preliminary Site Fencing
The site structures should be enclosed within a fence for security. The preliminary site plans indicate potential options for site fencing and access gates. Once the phase 2 improvements are added, fencing will be expanded as necessary to include all structures.

Reverse Osmosis Reject Water
The RO reject stream can potentially be handled in several ways including discharge to the sanitary sewer, a lagoon for evaporation, or deep well injection. Once design is initiated, disposal of the RO reject water must be evaluated in detail and a report discussing the plan submitted to the Kansas Department of Health and Environment for review. Disposal of the reject water will be a critical item in the design of the WTP. A thorough review of all options is necessary to determine the limitations of each option, feasibility of each option given the flow and waste stream strength that will be produced, and construction and operational costs. For site layout purposes, an area designated as a potential location for deep well injection of the RO reject flow is illustrated on the figures.

Estimated Costs

Cost estimates for the phase 1 improvements were prepared based on the structures and site layouts presented in Figures 1 and 2. These cost estimates are very preliminary and are based primarily on past project experiences. Project cost estimates are refined as designs progress, with the contingency values being reduced with each iteration. Given the very preliminary nature of this study and cost estimates, a contingency value of 30% of the construction cost was used. The estimated costs for each layout option is summarized in Table 1.

Table 1. Preliminary 1% Cost Estimates – Phase 1 Improvements

Item	Full Site (Figure 1)	10 Acres Removed (Figure 2)
Construction Cost	$122,100,000	$126,000,000
Legal/Administrative/Permitting	$18,400,000	$19,000,000
Engineering/Inspection	$18,000,000	$18,600,000
Total	$158,500,000	$163,600,000

The difference in the estimated construction costs is the work to fill in the existing pond. An approximate cost for this work is $3,000,000. This cost is based on the assumption that all material for filling the pond will be contractor supplied borrow material. With the need to raise the ground elevation for a substantial amount of the site based on the floodplain boundary, any excavated material from site improvements is planned to be wasted on site, and not necessarily be used for pond fill.

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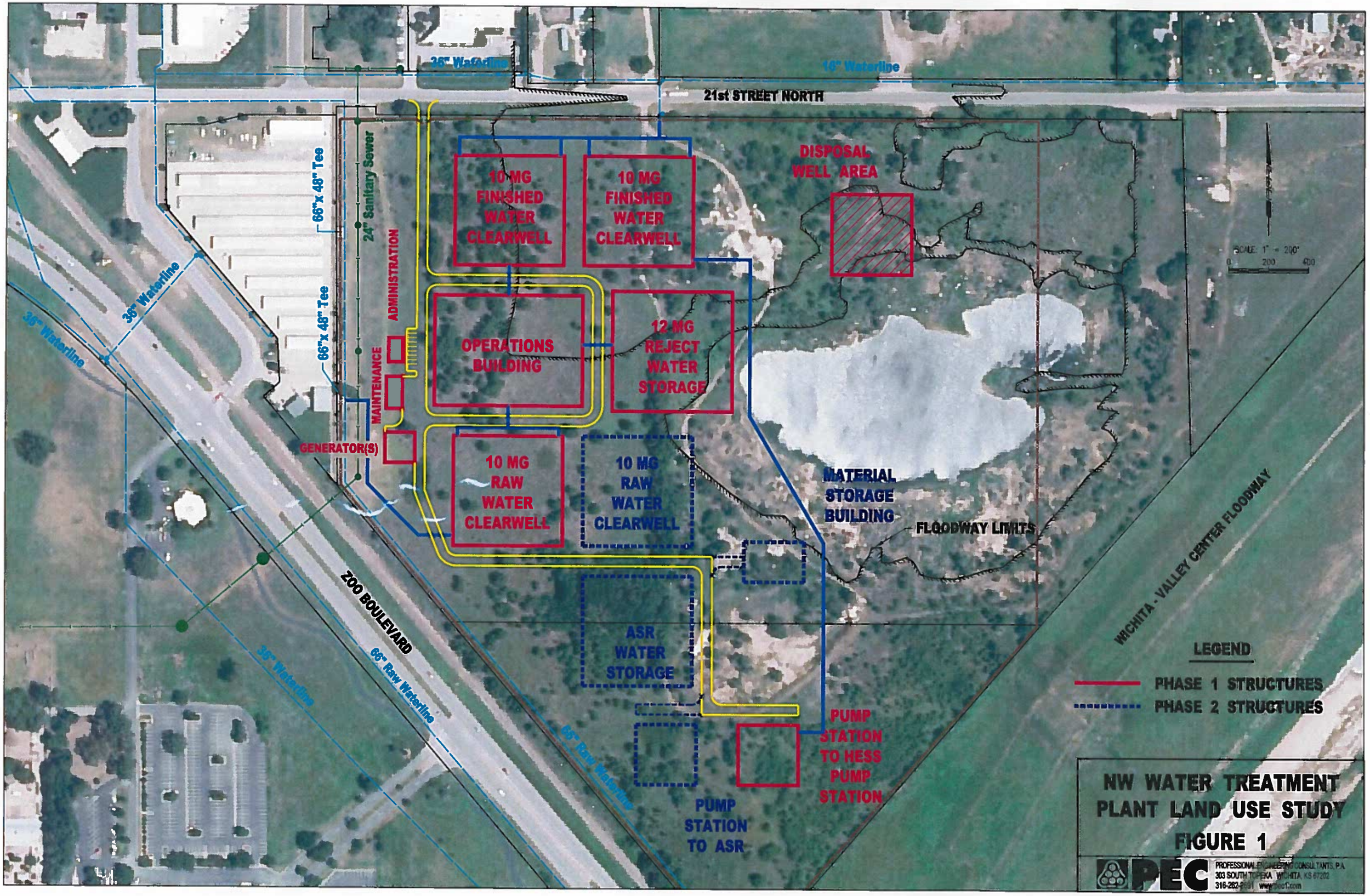

NW WATER TREATMENT PLANT LAND USE STUDY

FIGURE 1

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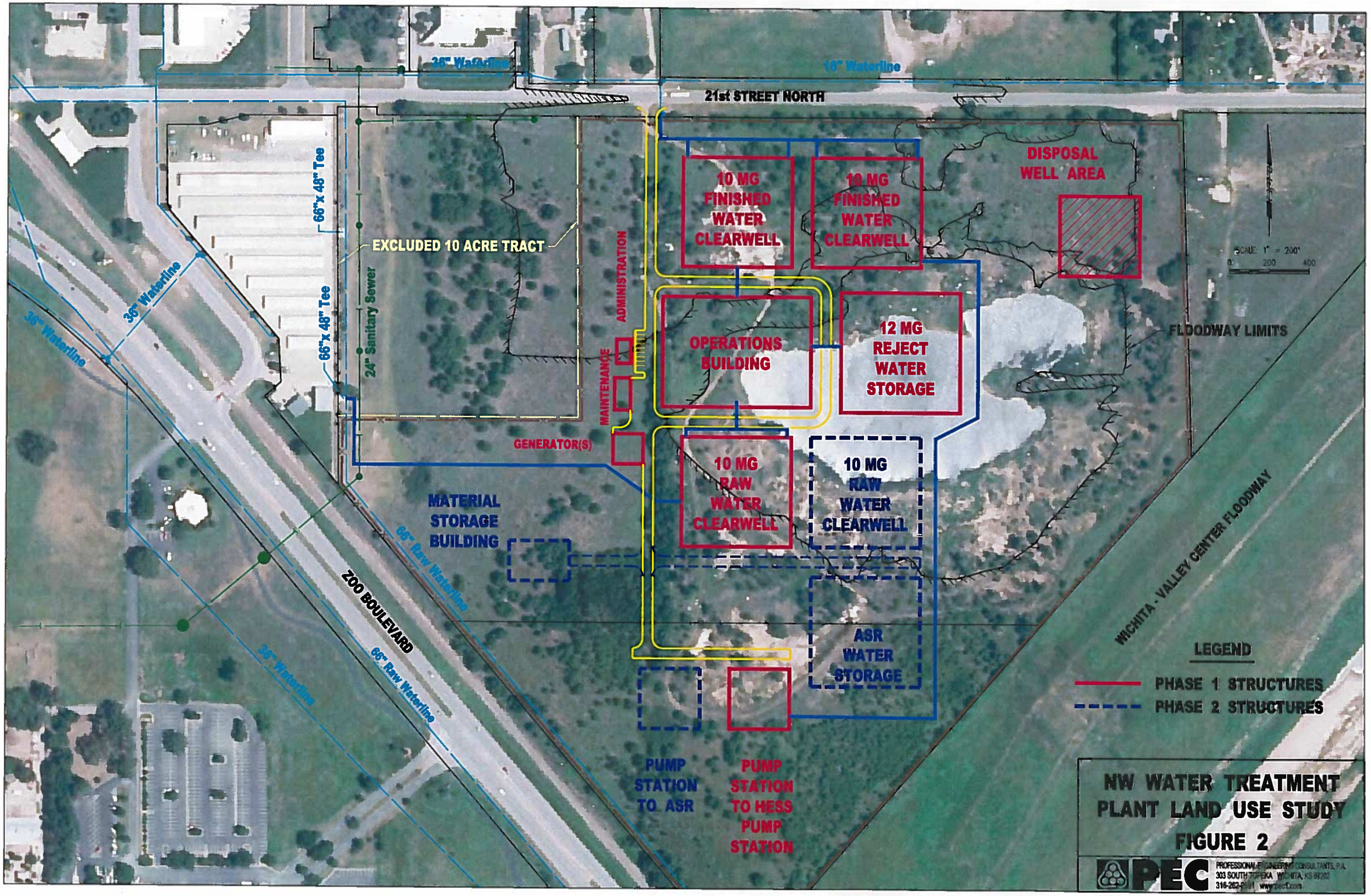
36" Waterline
16" Waterline
21st STREET NORTH
66"x 48" Tee
66"x 48" Tee
EXCLUDED 10 ACRE TRACT
24" Sanitary Sewer
ADMINISTRATION
MAINTENANCE
10 MG FINISHED WATER CLEARWELL
10 MG FINISHED WATER CLEARWELL
DISPOSAL WELL AREA
OPERATIONS BUILDING
12 MG REJECT WATER STORAGE
FLOODWAY LIMITS
SCALE: 1" = 200'
0 200 400
36" Waterline
36" Waterline
GENERATOR(S)
10 MG RAW WATER CLEARWELL
10 MG RAW WATER CLEARWELL
MATERIAL STORAGE BUILDING
66" Raw Waterline
ZOO BOULEVARD
66" Raw Waterline
36" Waterline
ASR WATER STORAGE
WICHITA - VALLEY CENTER FLOODWAY
LEGEND
PHASE 1 STRUCTURES
PHASE 2 STRUCTURES
PUMP STATION TO ASR
PUMP STATION TO HESS PUMP STATION
NW WATER TREATMENT PLANT LAND USE STUDY
FIGURE 2
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Appendix A

Geotechnical Report

GEOTECHNICAL REPORT

ALLIED
LABORATORIES
A Department of Professional
Engineering Consultants, P.A.

CITY OF WICHITA LAND USE STUDY

NORTHWEST WATER TREATMENT PLANT

WICHITA, KANSAS

Prepared For:

SARAH UNRUH, P.E.

PROFESSIONAL ENGINEERING CONSULTANTS, P.A.

WICHITA, KANSAS 67202

May 2015

Allied Project No: 74-15245-000-0147

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INTRODUCTION

This report presents the results of a geotechnical study for the development of a tract of land located approximately ¼ mile east of the intersection of West 21st Street North and North 55th Street West. The study was conducted to develop geotechnical recommendations for project design and is intended for the exclusive use of the client for the referenced project.

The geotechnical study included a field exploration program to obtain information on the subsurface conditions and collect samples for laboratory testing. The samples obtained during the field exploration were visually observed and classified in the laboratory. Representative samples were selected for laboratory testing to determine physical and engineering characteristics of the in-situ soils. Field exploration and laboratory test results were analyzed to develop geotechnical recommendations for the proposed construction. All field testing, laboratory testing, analysis, and report preparation was performed under the direction of a registered Professional Engineer.

The following sections present the results of the field exploration, laboratory tests, and our conclusions and recommendations for project design. The conclusions and recommendations are based on the project information available at the time of this report and the subsurface conditions encountered in the borings at the locations and times indicated. If project details including structure, and parking/drive locations, elevations, cut and fill depths or other conditions change during design or if the subsurface conditions vary from those described in this report, the conclusions and recommendations may need to be re-evaluated and adjusted.

SITE LOCATION AND DESCRIPTION

The site for the subject project is located approximately ¼ mile east of the intersection of West 21st Street North and North 55th Street West, Wichita, Kansas. The project area includes the existing city storage yard and dump site and a large pond (former sand pit).

Based on our visual observations at the time of our field exploration, the topography of the site is relatively level and is generally covered with trees, grass, and other low vegetation. However, the topography in the immediate area of the former sand pit varies significantly. The project site is bordered on the north by 21st Street North, on the south by Zoo Boulevard and railroad tracks, on the west by commercial properties, and on the east by the “Big Ditch”.

PROPOSED CONSTRUCTION

Although specific construction and design details for the project were not provided, we understand that the proposed project will include the construction of multi-story structures housing water treatment equipment and water storage basins, and also includes the construction of a parking and drive areas.

Paved drive and parking areas primarily for light to moderate vehicle traffic loads with occasional heavy vehicle loads are anticipated for this project.

Grading plans were not provided at the time of our evaluation; however, we have assumed that portions of the building may be founded on native soils and pavement areas will be supported on less than 1 to 2 feet of fill above the presently existing ground surface. It is also our understanding that the existing sand pit area may be filled, and the site leveled. Portions of the proposed structures may also be founded on this fill material.

Although detailed information has not been provided, structure foundation loads are anticipated to be relatively light. We have assumed the column, wall loads, and floor loads, will not exceed 35 kips, 4 kips per linear foot (klf), and 150 pounds per square feet (psf) respectively.

If actual building loads or fill/cut heights vary from these conditions, then the recommendations in this report may need to be re-evaluated. Any changes in these conditions should be provided so the need for re-evaluation of our recommendations can be assessed.

FIELD EXPLORATION

GENERAL

Boring locations and elevations were determined in the field by Allied Laboratories' drilling crew using the provided site plan and taped measurements from existing landmarks at the site and by using a handheld Global Positioning System (GPS). The boring locations should be considered accurate only to the degree implied by the method of measurement used. Approximate boring locations are shown on the attached Boring Location Plan (Figure 2).

STANDARD PENETRATION TEST BORINGS

The field exploration was conducted from May 19th through 22nd, 2015. A total of four (4) Standard Penetration Test (SPT) borings were performed to depths ranging from approximately 30.0 to 31.5 feet below the existing ground surface. SPT borings were drilled with either a Mobile Drill B-53 truck mounted drill rig or a Mobile Drill B-31 truck mounted drill rig, using 6-inch continuous flight auger.

Subsurface conditions in the boreholes were visually logged in the field by Allied Laboratories' personnel referencing ASTM D-2488 visual-manual procedures. Water level measurements were taken in the boreholes shortly after completion of drilling.

Samples of the subsurface soils were primarily obtained using a 2-inch O.D. split-spoon sampler. The sampler was driven into the strata using a 140-pound safety hammer falling 30 inches. The number of blows required to advance the sampler three successive 6-inch increments is recorded. The total number of blows used to advance the sampler the second and third 6-inch increment is the penetration resistance "N" value. Standard Penetration Test borings were performed referencing ASTM D-1586.

POND SOIL SAMPLING

During the site sampling procedures, six (6) relatively undisturbed soil samples were obtained at the Boring PB-1 through PB-6 locations (one per location) extending from the existing pond bottom to native soils. The samples were retrieved referencing ASTM D-1587 using 1-inch O.D. thin wall tube. The samples were sealed in the tubes and transferred to our laboratory for observation and testing.

LABORATORY TESTING

Soil samples obtained during the field exploration were observed and visually classified referencing ASTM D-2487 which is based on the Unified Soil Classification System (USCS). Selected samples were tested to evaluate engineering and physical properties. Tests performed included natural moisture content, Atterberg Limits, and percent passing the No. 200 sieve tests. Tests were performed referencing current ASTM procedures unless otherwise noted. Laboratory test results are summarized on the attached Summary of Exploratory Borings, Figures 3A through 3C; Exploratory Boring Logs, Log reports, Figures 4 through 13; and on the Laboratory Test Summary, Figure 15.

SITE CONDITIONS

This section presents brief descriptions of the subsurface conditions encountered at the SPT boring locations and general observations of the site. The attached Exploratory Boring Log (boring logs) reports should be reviewed for more information on the subsurface conditions at each boring location. Sharp transitions between soil types are presented on the boring logs. However, soil transitions may occur gradually and transition depths are approximate. The soil conditions noted on the boring logs are based on visual observations and periodic sampling. Additional sampling, testing and Petrographic analysis may provide a different classification of soil and bedrock types.

GENERAL

SPT Borings B-1 through B-4 were drilled to depths ranging from approximately 30.0 feet to 31.5 feet below existing site grade. The SPT Borings generally encountered 6 to 30 inches of topsoil underlain by sand soils with varying amounts of silt, clay, and gravel extending to boring termination depth. As an exception, approximately 48 inches of fill soils consisting of a Silty Sandy Clay with varying amounts of sand, concrete rubble, and gravel was encountered at the Boring B-2 location.

Soil sampling was also conducted within the existing sand pit to determine the approximate depths of muck and other deleterious materials that may be encountered during dewatering and fill operations at the site. Sampling of the muck and other deleterious soils (PB-1 through PB-6) were performed from the bottom of the sand pit, and were extended to native soils. Sampling results indicate that muck and other deleterious soils ranged in thickness from 0 inches to approximately 10 feet in thickness.

EXISTING FILL

Apparent fill materials consisting of a Silty Sandy Clay with varying amounts of sand, gravel, and concrete debris were encountered at the boring locations extending from below the ground surface to a depth of approximately 4.0 feet. The fill soils were predominantly characterized as moist, low to moderate plasticity, and a medium stiff to very stiff consistency.

It should be noted that it is possible that fill materials will be encountered, at varying depths, on unexplored portions of this site.

SOILS

SPT Borings B-1 through B-4 were drilled to depths ranging from approximately 30.0 to 31.5 feet below the existing ground surface. The native soil subsurface profiles primarily consisted of topsoil overlying layers of sand soils with varying amounts of silt, clay, and gravel, extending to boring termination depths.

The native silt soils encountered at the boring locations were characterized as dry to slightly moist, non-plastic, and with a stiff consistency. An SPT N value of 15 blows per foot of penetration was obtained for the encountered soil.

The native sand soils encountered at the boring locations were characterized as dry to saturated, with a very loose to medium dense relative density. The natural moisture content for the samples tested ranged from 1.9 to 8.3 percent. SPT N values ranged from 2 to 30 blows per foot of penetration.

GROUNDWATER

During and after drilling operations had ceased, near surface groundwater was observed to be present in Boring B-1 through B-4 borehole at depths ranging from approximately 14.0 to 19.5 feet below existing ground surface. The borings also indicated the presence of perched water pockets occurring within some of the encountered sand seams at varying depths throughout the site. Wet Cave of the soils was also encountered at Borings B-1, B-3, and B-4 at depths of 14.0, 28.5, and 9.0 feet below existing ground surface, respectively.

Groundwater levels may fluctuate several feet depending on climatic conditions, time of year, surface runoff, water levels in nearby streams or creeks, and other factors beyond the scope of this report. Groundwater may be present in these areas during wet periods and at various times of the year.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

Our geotechnical engineering evaluation of the surface and subsurface conditions at the site, with respect to the planned construction, are based on (1) our site observations, (2) the field and laboratory test data obtained, and (3) our understanding of the project information and structural conditions as presented in this report.

If the project information is incorrect, or should the location of the structures change, please contact the undersigned Engineer so that these recommendations can be reviewed. The discovery of any site or subsurface conditions during construction that deviate from the data obtained during this geotechnical exploration should also be reported to the undersigned Engineer for evaluation.

The recommendations presented in the subsequent sections of this report present design and construction techniques that are appropriate for the planned construction. We recommend that we be provided the opportunity to review the foundation plans and earthwork specifications to verify that our recommendations have been properly interpreted and implemented.

Based on the results of our exploration, we consider the subsurface conditions at the site adaptable for support of a lightly loaded structure when constructed on a properly designed conventional shallow foundation system founded on engineered fill. Provided the site preparation and earthwork construction recommendations outlined in this report are performed, the following parameters may be used for foundation design.

SITE DEMOLITION

Prior to demolition and construction operations, the location of existing underground utility lines within the construction area should be established. Provisions should then be made to relocate interfering utilities to appropriate locations.

Over-excavation and replacement of existing fill and isolated softer soils may also be necessary at this site due to previous excavation and fill operations. The extent of over-excavation will not be known until construction. The demolition, removal, and over-excavation operations should be closely monitored to ensure all debris is removed and all over-excavations are replaced with properly compacted, new engineered fill.

SITE GRADING

Ponded water can present significant problems during and after construction. Site grading plans should be designed to provide positive drainage away from all structures, slabs-on-grade, pavements and sidewalks. A minimum slope of 5 percent for the first 10 feet next to the structure and 2 percent thereafter is recommended for landscaped areas. Positive drainage should also be provided in all paved and sidewalk areas to the extent practicable within ADA requirements. All downspouts should be designed to discharge a minimum of 5 feet away from structures. Temporary drainage to a sump should be used to remove ponded water in excavations.

SUBGRADE PREPARATION

Prior to placing new fill; any unsuitable existing fill, soft soil, vegetation, and deleterious materials should be removed. Existing fill is present at this site due to previous construction activities. Therefore, over-excavation during grading may be required to remove any unsuitable existing fill materials.

Prior to construction operations, the location of existing underground utility lines within the construction area should be established. Provisions should then be made to relocate interfering utilities to appropriate locations.

After stripping and over-excavation (as necessary) operations are complete, the exposed subgrade should be proof-rolled by the contractor using a heavily loaded scraper, dump truck, or front-end loader to verify all soft areas have been excavated and that the subgrade is suitable for fill placement. The proof-roll should be observed by a qualified Engineering Technician under the direction of a Professional Engineer. The exposed subgrade should be scarified to a minimum depth of 8 inches; moisture conditioned and re-compacted to requirements outlined below.

Care should be exercised to avoid damaging any nearby above or below grade structures while the over-excavation, proof-roll and compaction operations are underway. These operations should cease if deemed detrimental, and the Geotechnical Engineer should be contacted immediately. It is recommended that the compaction equipment operate in static mode when adjacent structures are less than 50 feet from the edges of the construction area. We recommend monitoring and documentation of this compactive effort.

Any loose, yielding, or pumping soils identified during compaction will require stabilization with rock, drying and additional compaction, or undercutting and replacement with engineered fill. Once the native soils have been compacted and approved by a Geotechnical Engineer or their representative, structural fill placement can commence.

ENGINEERED FILL

All new fill should consist of clean soils free of debris and deleterious materials. Imported general fill should consist of clean soils with a maximum plasticity index of 25, or select fill.

Select fill should consist of Low Volume Change (LVC) materials including limestone gravel, limestone screenings, crushed sandstone, or equivalent. Natural LVC materials consisting of sandy clay, clayey sand or similar soils with a minimum of 20 percent passing the No. 200 sieve and a plasticity index between 5 and 15 may also be used with prior approval from the designers. The lower plasticity index may be waived if the fill is placed in confined conditions (i.e. inside stem walls). Actual application rates will need to be verified during construction.

Although the select fill options presented above provide for the necessary structural support, they may not necessarily provide a stable working surface for construction activities or inclement weather. The contractor should select the appropriate select fill materials for the anticipated construction traffic and to minimize weather delays if necessary.

All engineered fill should be placed under controlled conditions with observation and testing by a licensed Professional Engineer or designated representative. The following minimum compaction requirements and moisture requirements based on the *Standard Proctor (ASTM D-698)* are recommended.

- Footings, Pavement Stabilized Subbase — 98 % of Maximum Dry Density
- Structural Fill (Floor Slabs, Pavement) — 95 % of Maximum Dry Density
- Non-Structural Fill and Backfill — 90 % of Maximum Dry Density

The following moisture ranges are recommended for various soil types:

- Fat Clay, Lean Clay — Optimum Moisture Content to +4%
- Silts, Clayey Sand, LVC, Etc. — ± 3 % of Optimum Moisture Content
- Sands, Gravel — At Workable Moisture Content

New engineered fill should extend a minimum of 5 feet beyond any proposed building and structure footprints, and a minimum of 2 feet beyond the edges of all pavements. All fill should be placed in horizontal lifts with maximum compacted lift thickness of 6 inches (approximately 8 to 9 inches loose). Each lift should be evenly graded to provide a consistent lift thickness prior to placing additional lifts. Thinner lifts may aid compaction for energy sensitive soils (i.e. clay), or for light compaction equipment. Moisture sensitive soils (i.e. silt) may require stricter moisture control to achieve compaction. Potentially expansive clay soils should not be compacted more than 5 percent above the recommended minimum compaction requirements.

FOUNDATIONS

Based on the results of our exploration, we consider the subsurface conditions at the site adaptable for support of the proposed structures when constructed on a properly designed conventional shallow foundation system.

All footing excavations should be performed in a manner to avoid disturbing the soils below the bearing elevation. Hand excavation should be used to remove slough. Concrete should be placed for footings as soon as practicable after excavation to avoid drying or wetting of the exposed soils. If the bearing soils are disturbed, allowed to dry, or are wetted by rain or seepage water, remove the affected soil and extend the footings. Alternately, the over-excavated soil may be replaced with new engineered fill. All footing excavations should be observed by a qualified Geotechnical Engineer or Engineering Technician. Over-excavation and replacement of some soft soils and/or existing fill may be required at this site.

It should be noted that due to the varying material properties encountered at varying depths, foundations placed on different bearing materials may exhibit differential settlements that may exceed the tolerances of the structure. Because of these conditions, we recommend that prior to the design and construction of the structures, additional soil borings and analysis be performed within the footprint of the proposed structures to verify soil conditions, determine a more accurate bearing capacity, settlement, and differential settlement that may occur.

Depending on the soil conditions encountered at the time of construction, additional excavation and replacement may be required to provide a uniform material for bearing, and to help minimize long term structural settlement and differential settlements to the structure. The following recommendations may be used for general site design.

Native Sand Soils - A conventional shallow foundation system placed on native medium dense to dense sand soils encountered at depths of approximately 3.0 feet below existing site grade should be designed for a maximum allowable net soil bearing capacity of 3,000 psf to limit settlement and provide a minimum theoretical factor of safety against shear failure of 3. Net bearing pressure is defined as the soil bearing pressure at the foundation bearing level in excess of the natural

overburden pressure at that level. The foundations should be designed based on the maximum load that could be imposed by all loading conditions.

All exterior footings should be placed a minimum of 36 inches below finished grade to reduce the potential for adverse effects due to moisture variations of the near surface soils and frost. Minimum footing widths of 18 inches for continuous trench footings, and 42 inches for isolated column footings are recommended and were assumed for our analysis.

Based on our assumed foundation design and provided that the previous recommendations are performed, primary long term settlement for lightly loaded structures, with the footings designed using the recommendations presented above, is estimated to be approximately 1 inch. Differential settlement is estimated to be approximately 50 to 75 percent of the total settlement. The estimated settlements are approximate based on assumed footing details and depths. Additional settlement analysis may be warranted depending on final footing design and conditions encountered at the time of construction.

Engineered Fill Soils - A conventional shallow foundation system placed on new engineered fill should be designed for a maximum allowable net soil bearing capacity of 2,000 psf to limit settlement and provide a minimum theoretical factor of safety against shear failure of 3. Net bearing pressure is defined as the soil bearing pressure at the foundation bearing level in excess of the natural overburden pressure at that level. The foundations should be designed based on the maximum load that could be imposed by all loading conditions.

All exterior footings should be placed a minimum of 36 inches below finished grade to reduce the potential for adverse effects due to moisture variations of the near surface soils and frost. Minimum footing widths of 24 inches for continuous trench footings, and 60 inches for isolated column footings are recommended and were assumed for our analysis.

Based on our assumed foundation design and provided that the previous recommendations are performed, primary long term settlement for lightly loaded structures, with the footings designed using the recommendations presented above, is estimated to be approximately 1.5 inch. Differential settlement is estimated to be approximately 50 to 75 percent of the total settlement. The estimated settlements are approximate based on assumed footing details and depths. Additional settlement analysis may be warranted depending on final footing design and conditions encountered at the time of construction.

LATERAL EARTH PRESSURES

Below grade walls will be subject to lateral earth pressures. The magnitude of the lateral earth pressure is controlled by many factors including wall design, properties of the in-situ native and fill soils and backfill adjacent to the walls, drainage conditions, surcharge loads and other factors.

Significantly larger pressures will develop if backfill adjacent to the below grade or retaining walls becomes saturated. We recommend all retaining wall structures be designed with weep holes and backfilled using granular materials extending horizontally approximately 2 feet from the back of the wall. An appropriate filter wrapped drainage system designed to promote positive outfall should also be incorporated into the wall design. These measures are recommended to reduce the potential pressures on the retaining walls, the potential for saturation of the soils, and the possible detrimental effects due to shrink/swell of the fat clay soils.

The estimated pressure coefficients and equivalent fluid unit weights, are based on the soils encountered at the boring locations performed near the retaining wall locations and are shown in the following tables.

LVC Fill Soils (Estimated Moist Unit Weight = 122 pcf)		
	Coefficient	**Equivalent Fluid Unit Weight**
Active Pressure	0.59	72 pcf
At-Rest Pressure	0.74	90 pcf
Passive Pressure	1.69	207 pcf

In-situ and Granular Backfill Materials (Sand) (Moist Unit Weight = 115 pcf)		
	Coefficient	**Equivalent Fluid Unit Weight**
Active Pressure	0.30	35 pcf
At-Rest Pressure	0.47	54 pcf
Passive Pressure	3.25	374 pcf

Significantly larger pressures will develop below the groundwater level. An active equivalent fluid pressure of 75 pcf and an at-rest pressure equivalent fluid pressure of 90 pcf should be used for design of structures with a non-cohesive granular backfill that extends below the water level.

The passive pressures and coefficient of friction are used to resist sliding and lateral forces. A coefficient of friction of 0.3 is recommended. The at-rest case should be used if the walls are rigid and little or no rotation is anticipated. Below grade walls should only be designed for the active case if walls are allowed to rotate sufficiently to fully mobilize active pressure.

The earth pressure parameters provided above do not include surcharge loads (i.e., structure loads, fill loads, forces from construction equipment). Appropriate safety factors and surcharge loads should be applied to these values. The parameters also do not account for hydrostatic pressures.

FLOOR SLABS

The near surface soils had minimal variation across the site. For the encountered conditions, a minimum of 6 inches of select fill is recommended below all at grade or near grade floor slabs. Lower portions of the new fill used to develop the design grades may consist of on-site sand soils, or imported general fill with a maximum plasticity index of 30. For all below grade floor slabs to be founded over the native sand soils, no LVC or select fill should be required unless required to make grade.

In addition to the select fill, a minimum of 4 inches of a granular leveling course/moisture barrier is recommended below at-grade floor slabs with moisture sensitive floor coverings. The leveling course/moisture barrier may consist of a clean, coarse grained sand or clean gravel. An appropriate synthetic moisture barrier should also be used for moisture sensitive floor coverings as recommended by the floor covering manufacturer. Care should be taken to protect vapor barrier material from puncture and tearing during construction.

Prior to placing select fill (LVC) or new engineered fill, the subgrade should be prepared according to the Subgrade Preparation and Engineered Fill sections of this report. All utility lines entering the building should be sealed to prevent migration of surface and subsurface water and subsequent wetting of the subgrade soils. The utility lines should be sealed from the building foundation to a minimum of 3 feet outside the building foundation. The seal may consist of clay soils with a minimum plasticity index of 25 or lean concrete.

The above recommendations provide for a stabilized/moisture conditioned zone below the floor slab. These recommendations are intended to reduce the potential for floor slab movement due to swell or shrink of the site soils without adding undue costs to the project. However, some differential movement may still occur between floor slabs and foundations due to shrink/swell of the site soils or differential settlement between the foundations and floor slabs. The potential for damage due to relative differential movement between the footings and floor slab may be reduced by isolating the floor slab from all bearing walls and columns to allow unrestrained vertical movement and to restrict load transfer to and from the structure.

These recommendations do not necessarily address the potential for significant differential movement due to extreme moisture changes caused by excessive drying or saturation of the subgrade soils. Causes for excessive moisture changes can include leaking utility lines, poor surface or subsurface drainage, inadequate sealing of joints, and others. If project design includes items which can contribute to excessive moisture changes in the subsurface soils, the recommendations may need to be re-evaluated and adjusted, and additional preventative measures may be required.

TEMPORARY GROUNDWATER CONTROL

Across the site, the near surface groundwater level was encountered at depths ranging from approximately 14.0 to 19.5 feet below existing grade at the time of our exploration. Based on this, it may be necessary to install temporary groundwater control measures to dewater these areas to facilitate the excavation process. The water table should be maintained at least 2 feet below the required depth of excavation. The groundwater control measures should be determined by the contractor. Care should be taken during dewatering operations not to impact the foundation soils of the existing structures.

The site should be graded to direct surface water runoff from the construction area. Also, deeper excavations may expose confined water-bearing seams where relatively permeable sands underlie less permeable clay soils. It is recommended that these permeable zones be dewatered to prevent heave or “boiling” of the subgrade soils.

HYDROSTATIC UPLIFT PRESSURES

Below grade structures should be designed to resist lateral earth pressures and hydrostatic uplift pressures appropriate for their depth below existing grade and the normal seasonal high groundwater table.

Groundwater or perched water tables were encountered near the anticipated bottom of floor elevation for the below grade structures. In addition, groundwater levels will be subject to seasonal or climatic fluctuations. Due to the current groundwater conditions and the unpredictable nature of seasonal groundwater and perched water table elevations, it is recommended that both a permanent dewatering system be installed and a positive means of uplift protection be implemented for the below grade structures. Hydrostatic uplift forces can be resisted in several ways including:

- Addition of dead weight to the structure.
- Mobilizing the dead weight of the soil surrounding the structure through extension of footings outside the perimeter of the structure.

At your request, we would be pleased to assist you in evaluating uplift protection requirements.

PERMANENT GROUNDWATER CONTROL

Our evaluation of the groundwater and the soil conditions at the proposed below grade structures indicated that waterproofing the walls and the installation of a permanent underdrain system with a positive outfall may be required depending on final site grades. Because of the fine grained sand and silty sand soils at the assumed floor slab elevation, it is our opinion that a typical underdrain or edge drain system may have an increased potential to become clogged and, therefore require

substantially more maintenance than a blanket drain. A blanket drain system beneath the below grade structure concrete slabs should be designed to draw down the static groundwater table beneath the slab and, thereby, mitigate the potential for groundwater seepage into the below grade structure areas after construction.

The construction of the blanket drain will require over-excavating the soils below the floor slab level a minimum of 24 inches. A relatively light weight non-woven geotextile (Amoco 4535 or equivalent) should be placed at the bottom of the excavation. The filter fabric should be placed such that the sides of the excavation are also covered. Aggregate material (ASTM C-33 size, No. 57 stone, or equivalent) should be used to backfill beneath the slab.

The underdrain system should be designed by a Drainage Engineer or Hydrogeologist and should include perforated “feeder” pipes with sock coverings, non-woven geotextile fabric to mitigate the migration of fines into the aggregate material, a “header” pipe connected to the “feeder” pipes and sloped downward to a positive outfall or sump-pump.

It should be noted that whenever pumping is used for the removal of groundwater, care must be taken not to damage adjacent buildings which may be in danger because of the depressed cone of drawdown (if applicable at the time of construction). Permanently lowering the groundwater level in compressible silts and clays can lead to settlement and distress of adjacent buildings that rest on these formations.

Alternately, if an underdrain system is not chosen for design, the design team may choose a passive system and design the structure to be impervious to water intrusion through design of the structure and/or providing a fully sealed waterproof barrier under and around the structure to grade level. It should be noted, that allowing the perched groundwater to remain at the foundation level of the structure could result in reduced bearing capacity of the soils due to the saturated soil conditions.

PAVEMENT

Pavement performance is directly related to the physical properties of the subgrade soils and traffic loading. Design traffic information was not available when preparing this report and was assumed to be light to moderate for drive lanes used by passenger vehicles and delivery trucks.

The subgrade soils in the exploratory borings typically consisted of silty sand and sand soils. California Bearing Ratio (CBR) values for the silty sand and sand soils range from 10 to 40. Based on these conditions, we recommend a stabilized subbase be placed below all pavement sections. Prior to placing the stabilized subbase, the existing subgrade should be prepared according to the Subgrade Preparation and Engineered Fill sections of this report.

A stabilized subbase may consist of imported AB-3 gravel or equivalent. Chemical stabilization of sand soils may also be used. Typically, the addition of 15 percent class C fly-ash is sufficient to

stabilize the sand soils. The exposed subgrade should be tested during construction in order to evaluate the appropriate stabilizing agent and application rate.

Based on assumed traffic loading, the following typical pavement sections are presented for light and moderately loaded pavements. These sections are typical sections based on assumed pavement loads. Additional analysis and thicker pavement sections may be needed for heavy traffic and vehicle loads.

FLEXIBLE PAVEMENT		
PAVEMENT SECTION	**LIGHT LOADS**	**MODERATE LOADS**
Wearing Course (BM-2)[1]	2 inches	2 inches
Base Course (BM-4)[1]	3 inches	5 inches
Stabilized Subbase[2]	6 inches	8 inches

RIGID PAVEMENT		
PAVEMENT SECTION	**LIGHT LOADS**	**MODERATE LOADS**
Portland Cement Concrete	5 inches[3]	6 inches[3]
Stabilized Subbase[2]	8 inches	8 inches

[1] KDOT Asphaltic Concrete Designations
[2] Compacted AB-3 gravel, chemically stabilized soil, or equivalent
[3] Minimum recommended thickness due to construction tolerances

Rigid pavement is recommended for areas where heavy vehicles will be turning and stopping. These areas include truck routes, loading and unloading zones and trash receptacle areas. A minimum of 8 inches of rigid concrete is recommended for delivery truck lanes and trash receptacle areas.

Asphaltic concrete pavement should consist of a plant mixture composed of aggregate and bituminous material which meets the requirements of KDOT specifications established by a qualified engineer. Concrete should be based on a mix design prepared by a qualified engineer.

The stabilized subbase sections presented in the table above do not incorporate the use of a subgrade separation fabric, or subgrade reinforcement fabric. Depending on fill materials used to raise site grades, the use of either of the above subbase improvement fabrics may be needed to

help prolong the life of the pavement sections or reduce the required thickness of the stabilized subbase.

The pavement sections presented are based on an estimated service life of 20 years. However, periodic maintenance including crack sealing and overlays may be required to achieve the service life. The performance and service life of the pavement will be significantly affected by poor surface and subsurface drainage. Adequate surface drainage and crack sealing should be maintained throughout the life of the pavement.

SEISMIC

The soil profiles encountered at the site consists primarily of very loose to medium dense sand soils. Standard penetration test (SPT) values ranging from 2 to 30 blows per foot of penetration within the encountered sand soils. Based on these conditions and our experience with similar projects in this area, the site should be characterized as Class D for seismic design according to the International Building Code (IBC) site classification definitions outlined in Table 1615.1.1. and in American Society of Civil Engineers (ASCE) 7.

EXCAVATIONS

All excavations should be constructed and/or shored according to local, state, federal and OSHA requirements. Each excavation must be evaluated during construction by the responsible person to determine appropriate sloping, shoring and excavation techniques. Maximum OSHA recommended slopes for temporary excavations less than 20 feet deep with simple slopes include the following:

Stable Rock - vertical, Type A (stiff soils) - 3/4 H to 1 V, Type B (medium stiff soils) - 1 H to 1 V, Type C (soft soils/sands) - 1.5 H to 1 V. These classifications are presented for general information only and preliminary design only. OSHA regulations should be reviewed for details regarding soil strengths, sloping/shoring requirements and other guidelines.

QUALITY CONTROL TESTING

We recommend that Allied Laboratories be retained to perform the construction material testing and observations required for this project, to verify that our recommendations have been satisfied. Due to our familiarity with the project and the intent of our engineering design, we are the most qualified to efficiently address any problems that may arise during construction.

A representative number of field in-place density tests should be made in the upper 2 feet of compacted soils, in each lift of compacted backfill and fill, and in the upper 12 inches below the bearing levels in the footing excavations. The density tests are considered necessary to verify that satisfactory compaction operations have been performed. It is recommended that density testing

be performed (1) at a minimum of 3 locations within each building area, (2) at 25 percent of the isolated column footing locations, (3) at one location for every 50 linear feet of continuous wall footings, and (4) at one location for every 10,000 square feet of pavement.

GENERAL NOTES AND LIMITATIONS

The recommendations presented are based on experience with similar soils in this area. The owner should be aware that there is a risk for construction on these soil types. Performance of the structures depend on following the design recommendations and maintenance after construction. This requires positive drainage away from the structures, and may require restricted planting and watering adjacent to the structures.

Geotechnical recommendations are based on periodic sampling in widely spaced, small diameter borings and subsurface conditions may vary from those encountered in the borings. Our scope of services was intended to evaluate the soil conditions within the zone of soil influenced by the foundation systems. Our scope of services does not address geologic conditions, such as sinkholes or soil conditions existing below the depth of the soil borings.

No other warrantees or guarantees are intended. The nature and extent of subsurface conditions may vary across the site. If subsurface conditions are encountered other than described in this report, the recommendations presented may need to be re-evaluated and adjusted.

ALLIED LABORATORIES
*Department of **P**rofessional **E**ngineering **C**onsultants, P. A.*

Prepared by:

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Senior Geotechnical Engineer

attachments

ALLIED LABORATORIES
DEPT. OF PEC, P.A.
350 SOUTH WASHINGTON
WICHITA, KANSAS

APPENDIX

FIELD EXPLORATION AND LABORATORY TEST RESULTS

City of Wichita Land Use Study
Northwest Water Treatment Plant
Wichita, Kansas
Allied Project Number: 74-15245-000-0147

SITE LOCATION MAP ..... Figure 1

BORING LOCATION PLAN ..... Figure 2

SUMMARY OF EXPLORATORY BORINGS ..... Figures 3A – 3C

EXPLORATORY BORING LOGS ..... Figures 4 - 13

KEY TO SYMBOLS ..... Figure 14

SUMMARY OF LABORATORY TEST RESULTS ..... Figure 15

SOIL CLASSIFICATION CHART ..... Figure 16

GENERAL GEOTECHNICAL NOTES ..... Figure 17

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SITE LOCATION MAP

City of Wichita Land Use Study
Northwest Water Treatment Plant
Wichita, Kansas
Allied Project Number: 74-15245-000-0147

Figure 1

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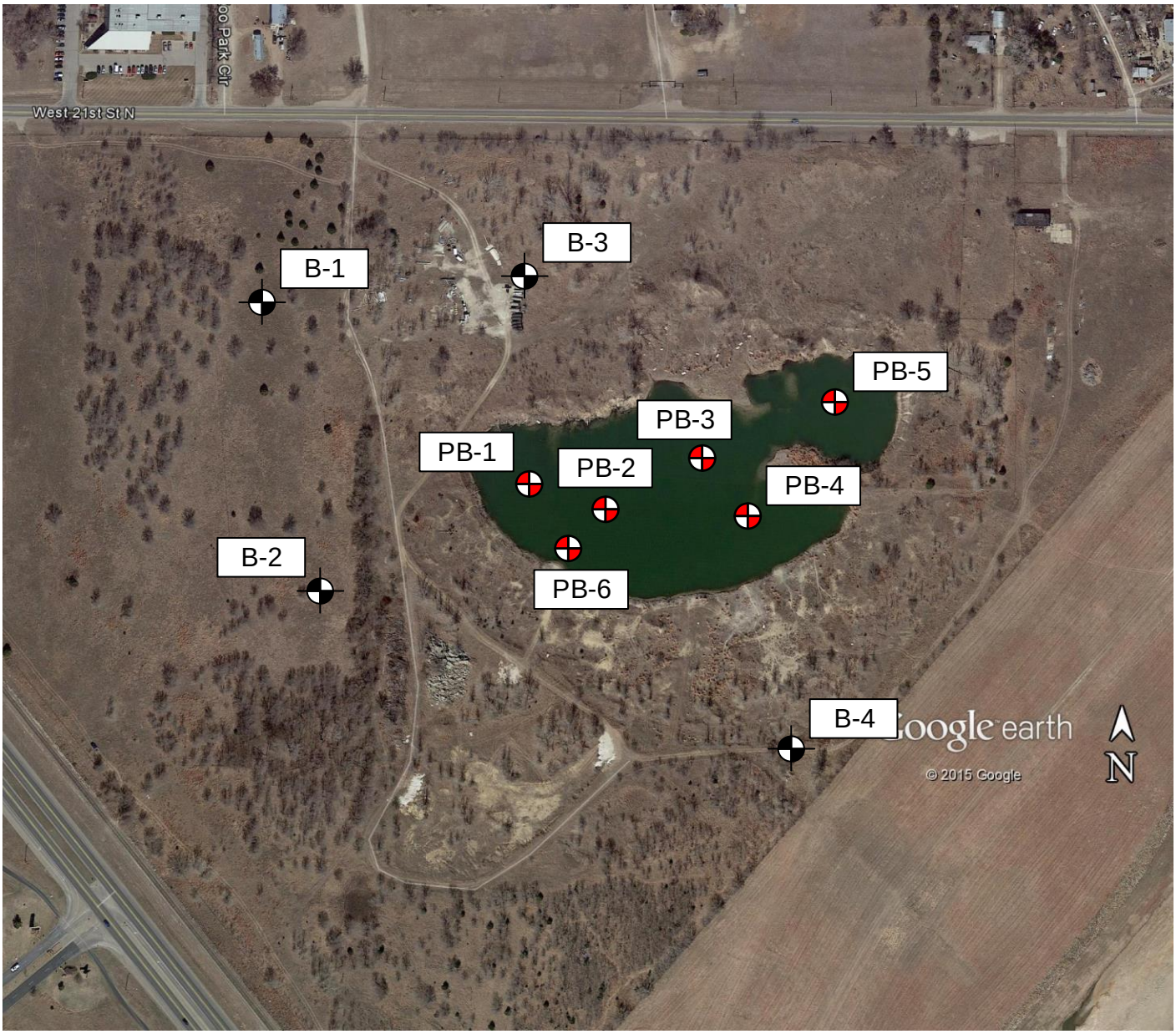
WICHITA, KANSAS

BORING LOCATION PLAN

City of Wichita Land Use Study
Northwest Water Treatment Plant
Wichita, Kansas
Allied Project Number: 74-15245-000-0147



No Scale

Standard Penetration Test Boring
Approximate Location

Test Sample Approximate Location

Plan provided by client for Boring location illustration only.
Not for Construction.

Figure 2

Allied Laboratories
Dept. of PEC
350 South Washington
Wichita, Kansas 67202

SUMMARY OF EXPLORATORY BORINGS

City of Wichita Land Use Study for Water Treatment Plant

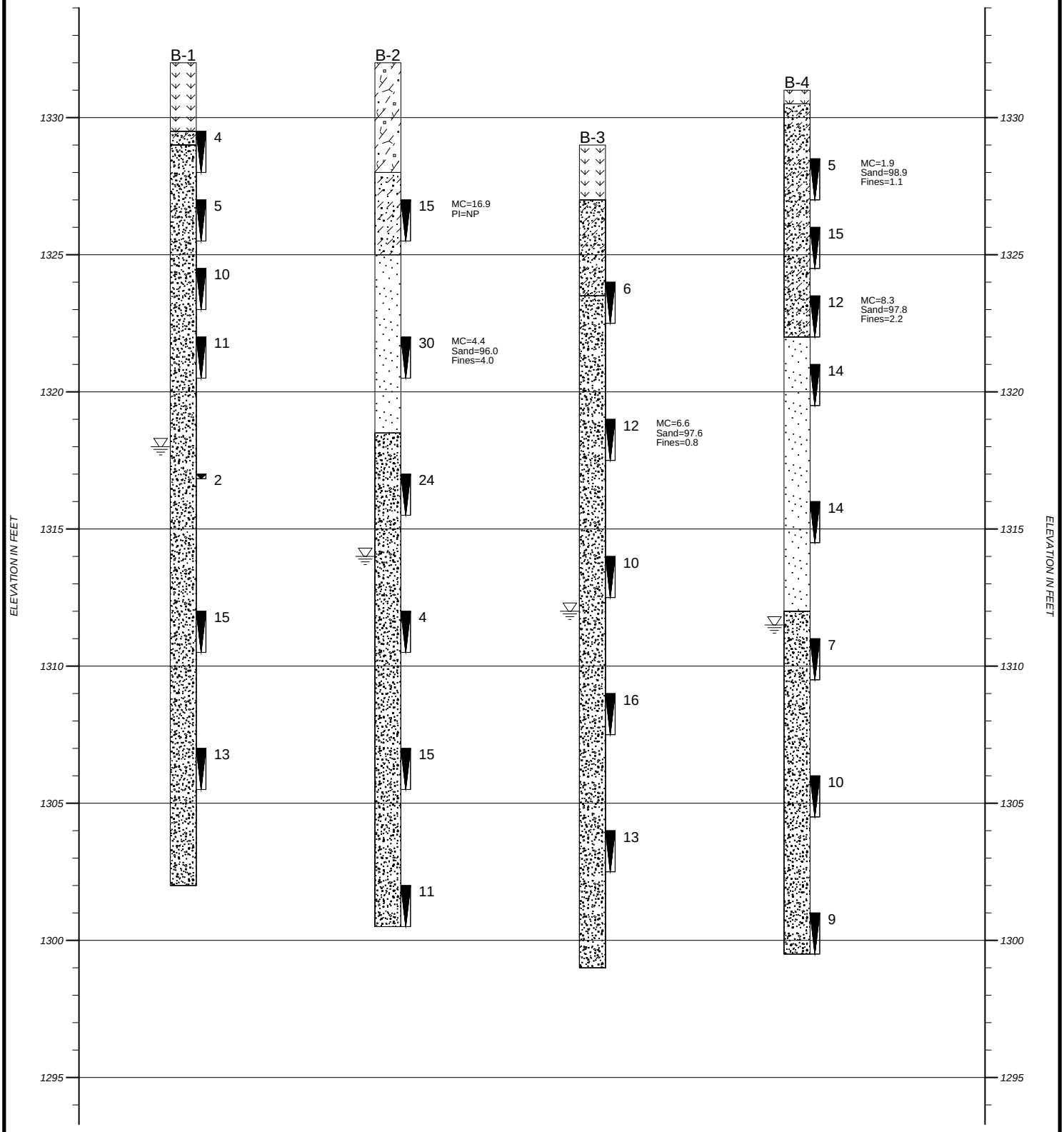


Figure 3A

Allied Laboratories
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Wichita, Kansas 67202

SUMMARY OF EXPLORATORY BORINGS

City of Wichita Land Use Study for Water Treatment Plant

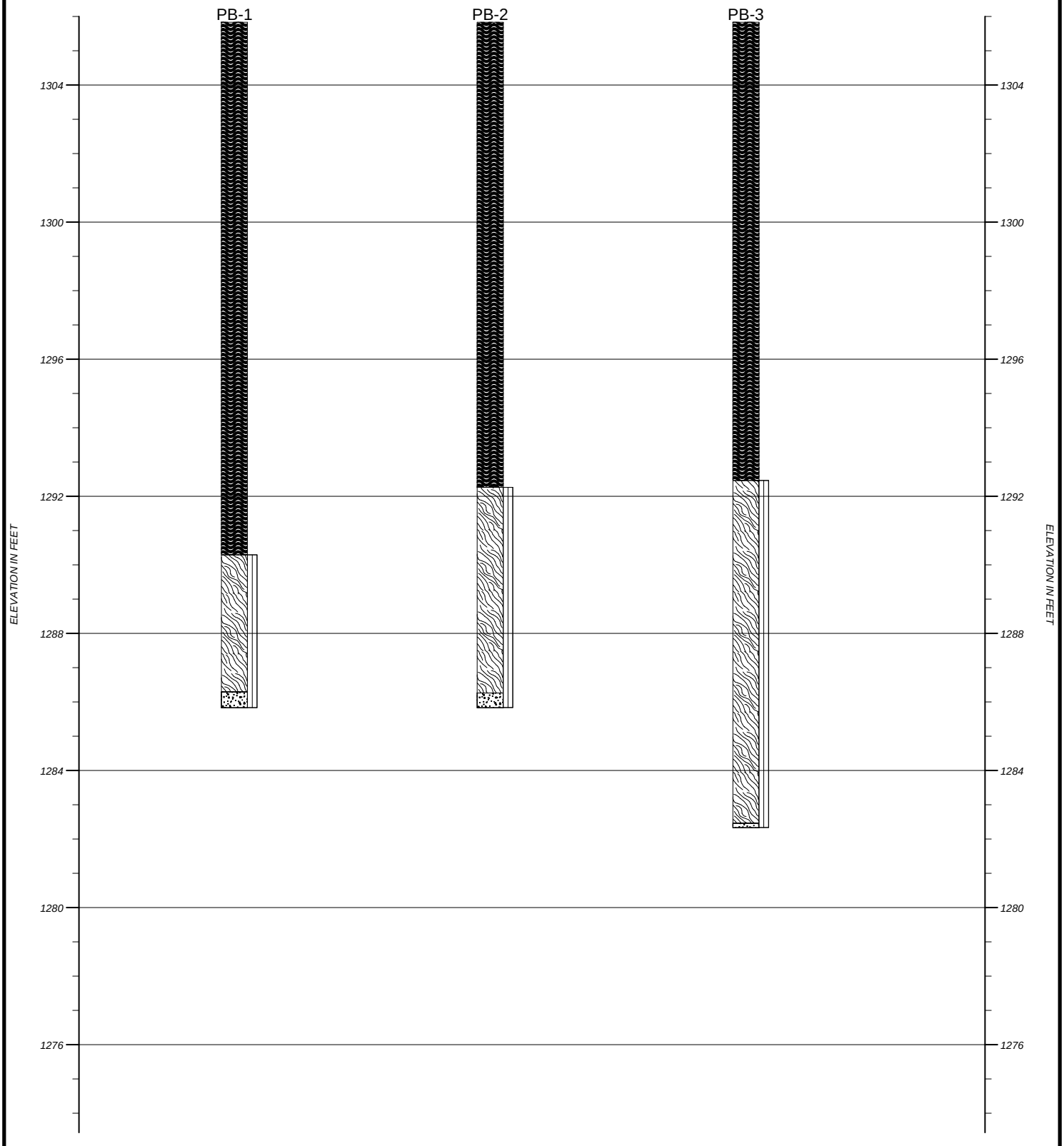

Figure 3B

Allied Laboratories
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350 South Washington
Wichita, Kansas 67202

SUMMARY OF EXPLORATORY BORINGS

City of Wichita Land Use Study for Water Treatment Plant

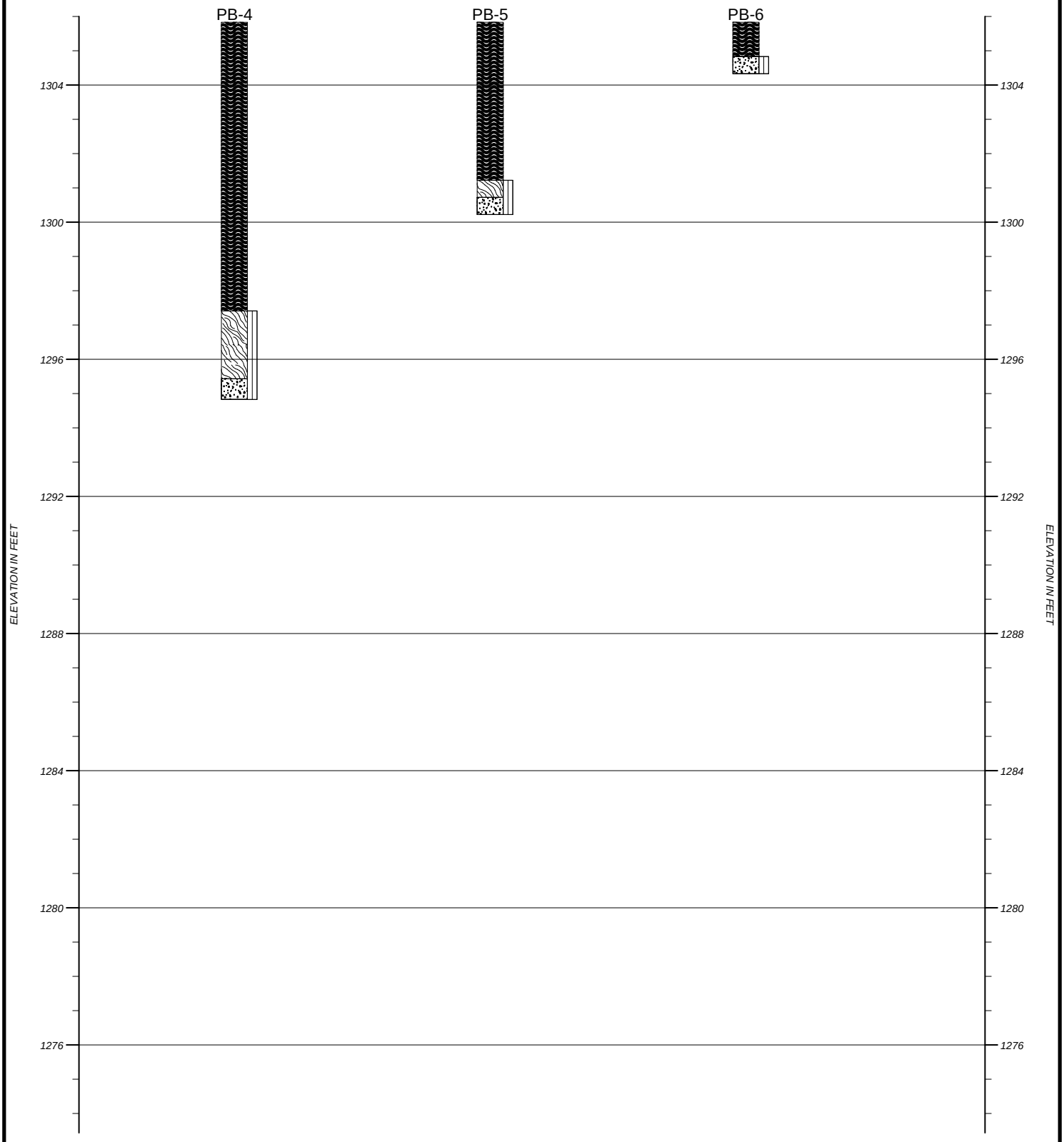

Figure 3C

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350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-1

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/20/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **14.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: **14.0** | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1332	TOPSOIL (30 inches), Silty Sandy Clay, dark brown, some fine grained sand, some organic materials, moist, soft														
2.5	1329.5	SILTY SAND, dark brown, fine grained sand		B1-1	P	18	3 1 3	**4**								
	1329	trace organic materials, moist, loose														
		SAND, yellowish tan, fine to medium grained, moist, loose														
5		SAND, brown, fine to coarse grained, trace fine gravel, moist, loose		B1-2	P	18	3 2 3	**5**								
7.5				B1-3	P	18	4 5 5	**10**								
10				B1-4	P	18	7 6 5	**11**								
12.5																
		SAND, tan, fine to coarse grained, trace fine gravel, wet, loose to medium dense														
15				B1-5	P	2	1 2	**2**								
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 4

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-1

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/20/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **14.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: **14.0** | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
	20			B1-6	P	18	6 7 8	**15**								
	22.5															
	25	SAND, tan, fine to coarse grained, trace fine gravel, wet, loose to medium dense		B1-7	P	18	6 6 7	**13**								
	27.5															
	30	1302 End of boring at 30 feet.		B1-8	G											
	32.5															
	35															

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 4

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Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-2

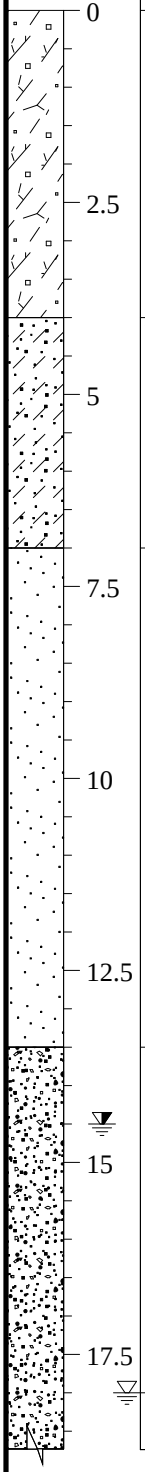
City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/19/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **18.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL: **14.5'**

WET CAVE: | DRY CAVE: | NOTES:



Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
1332	FILL (48 inches), Silty Sandy Clay, brown, many organic materials, fine to coarse grained sand, concrete debris seams, dry, medium stiff														
1328	SANDY SILT, tan, some fine grained sand, slightly moist to dry, stiff		B2-1	P	18	6 7 8	**15**	16.9							NP
1325	SAND, tan, fine grained, trace silt, dry, medium dense		B2-2	P	18	12 15 15	**30**	4.4			0.0	96.0	4.0		
1318.5	SAND, tan, fine to coarse grained, trace fine gravel, moist to wet, medium dense		B2-3	P	18	8 11 13	**24**								
	SAND, tan, fine to coarse grained, trace fine gravel, wet, loose														

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 5

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-2

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/19/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **18.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL: **14.5'**

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
				B2-4	P	18	3 2 2	**4**								
				B2-5	P	18	6 6 9	**15**								
				B5-6	P	18	4 6 5	**11**								
	1300.5	End of boring at 31.5 feet.														

20 22.5 25 27.5 30 32.5 35

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 5

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-3

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/20/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **17.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: **9.0'** | DRY CAVE: | NOTES: **Wet cave at 11.0 feet and 9.0 feet**

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1329	TOPSOIL (24 inches), Silty Lean Clay, dark brown, some fine grained sand, some organic materials, moist, soft														
2.5	1327	SILTY SAND, brown, fine grained sand, trace organic materials, moist, loose														
5	1323.5	SAND, tan, fine to coarse grained, moist, loose		B3-1	P	18	4 3 3	**6**								
7.5		SAND, brown, fine to coarse grained, trace clay seams, trace gravel, moist, medium dense														
10		SAND, tan, fine to coarse grained, trace fine gravel, moist, medium dense		B3-2	P	18	6 6 6	**12**	6.6			1.6	97.6	0.8		
12.5																
15				B3-3	P	18	5 4 6	**10**								
17.5		SAND, tan, fine to coarse grained, trace fine gravel, wet, medium dense														

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 6

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-3

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/20/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **17.0** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: **9.0'** | DRY CAVE: | NOTES: **Wet cave at 11.0 feet and 9.0 feet**

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
20		SAND, tan, fine to coarse grained, some fine gravel, trace clay seams, wet, medium dense		B3-4	P	18	5 8 8	**16**								
22.5																
25		SAND, tan, fine to coarse grained, some fine gravel, wet, medium stiff		B3-5	P	18	3 6 7	**13**								
27.5																
30	1299	End of boring at 30 feet.		B3-6	G											
32.5																
35																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 6

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-4

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/19/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **19.5'** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL: **17.5'**

WET CAVE: **28.5** | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1331	TOPSOIL (6 inches), Silty Sandy Clay, brown, many organic materials, fine grained sand, moist, medium stiff														
	1330.5	SILTY SAND, tan, fine grained sand, slightly moist, loose to medium dense														
2.5				B4-1	P	18	3 3 2	**5**	1.9			0.0	98.9	1.1		
5				B4-2	P	18	6 8 7	**15**								
7.5				B4-3	P	18	4 7 5	**12**	8.3			0.0	97.8	2.2		
	1322	SAND, tan, fine grained, slightly moist, medium dense														
10				B4-4	P	18	6 6 8	**14**								
12.5																
15				B4-5	P	18	10 8 6	**14**								
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 7

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-4

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/19/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: **19.5'** | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL: **17.5'**

WET CAVE: **28.5** | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
	1312	SAND, tan, fine to coarse grained, trace fine gravel, wet, loose														
20				B4-6	P	18	3 4 3	**7**								
22.5																
25				B4-7	P	18	3 4 6	**10**								
27.5																
30				B4-8	P	18	5 4 5	**9**								
	1299.5	End of boring at 31.5 feet.														
32.5																
35																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 7

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-1

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
2.5																
5																
7.5																
10																
12.5																
15																
	1290.29	POND BOTTOM (48 inches), Silty Sand, black, fine grained sand, many organic materials, saturated, very loose														
17.5				PB1-1	R	53.5										

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 8

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-1

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147**	BORING LOCATION: **See Boring Location Plan**			
SCALE: 1 IN= 2.5 FT.	BORING DATE **5/22/2015**	DRILLER **BH**	LOGGED BY **NS**	CHECKED BY **HM**
WATER LEVEL @ DRILL:	24 HOUR WATER LEVEL:	WATER LEVEL AFTER DRILL:		
WET CAVE:	DRY CAVE:	NOTES:		

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
20	1286.29	SAND, tan and dark gray mixed, fine to medium grained, saturated, very loose														
	1285.83	End of boring at 20 feet.														
22.5																
25																
27.5																
30																
32.5																
35																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 8

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-2

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
2.5																
5																
7.5																
10																
12.5																
15	1292.26	POND BOTTOM (70 inches), Silty Sand, black, fine grained sand, many organic materials, saturated, very loose		PB2-1	R	77.1										
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 9

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-2

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147**	BORING LOCATION: **See Boring Location Plan**			
SCALE: 1 IN= 2.5 FT.	BORING DATE **5/22/2015**	DRILLER **BH**	LOGGED BY **NS**	CHECKED BY **HM**
WATER LEVEL @ DRILL:	24 HOUR WATER LEVEL:	WATER LEVEL AFTER DRILL:		
WET CAVE:	DRY CAVE:	NOTES:		

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
20	1286.26	SAND, tan and dark gray mixed, fine to medium grained, saturated, very loose														
	1285.83	End of boring at 20 feet.														
22.5																
25																
27.5																
30																
32.5																
35																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 9

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-3

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
2.5																
5																
7.5																
10																
12.5																
15	1292.46	POND BOTTOM (120 inches), Silty Sand, black, fine grained sand, many organic materials, saturated, very loose		PB3-1	R	121.5										
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 10

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-3

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
20																
22.5																
	1282.46 1282.33	SAND, tan and dark gray mixed, fine to medium grained, saturated, very loose														
		End of boring at 23.5 feet.														
25																
27.5																
30																
32.5																
35																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 10

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-4

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
2.5																
5																
7.5																
	1297.41	POND BOTTOM (24 inches), Silty Sand, black, fine grained sand, many organic materials, saturated, very loose		PB4-1	R	31.0										
10	1295.43	SAND, tan and dark gray mixed, fine to medium grained, saturated, very loose														
	1294.83	End of boring at 11 feet.														
12.5																
15																
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 11

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-5

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
2.5																
5	1301.22	POND BOTTOM (6 inches), Silty Sand, black, fine grained sand, many organic materials, saturated, very loose		PB5-1	R	12										
	1300.72															
	1300.22	SAND, tan and dark gray mixed, fine to medium grained, saturated, very loose														
7.5		End of boring at 5.61 feet.														
10																
12.5																
15																
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 12

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

PB-6

City of Wichita Land Use Study for Water Treatment Plant

PROJECT NO: **74-15245-000-0147** BORING LOCATION: **See Boring Location Plan**

SCALE: 1 IN= 2.5 FT. | BORING DATE **5/22/2015** | DRILLER **BH** | LOGGED BY **NS** | CHECKED BY **HM**

WATER LEVEL @ DRILL: | 24 HOUR WATER LEVEL: | WATER LEVEL AFTER DRILL:

WET CAVE: | DRY CAVE: | NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	1305.83	Water														
	1304.83	SAND, tan, fine to medium grained, trace organic material, saturated, very loose		PB6-1	R	6										
	1304.33	End of boring at 1.5 feet.														
2.5																
5																
7.5																
10																
12.5																
15																
17.5																

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 13

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LEGEND

City of Wichita Land Use Study for Water Treatment Plant

Strata symbols

- Topsoil
- Silty sand
- Sand
- Fill
- Sandy Silt
- Well graded sand
- Water
- Pond Bottom

Misc. Symbols

- Boring continues
- Water level during drilling
- Depth to Wet Cave after drilling
- Water Level: approx. 72 hours after drill

Soil Samplers

- (P) 2" OD Splitspoon Sampler Standard Penetration Test
- (R) 1" OD Thin Wall Tube Sampler

Notes:

Exploratory borings were drilled on the dates indicated on the boring logs. Borings were drilled with a Mobile Drill B-53 rotary drill rig or a Mobile Drill B-31 drill rig using 6 inch continuous flight auger and/or 3-1/4 inch ID hollow stem auger.

Groundwater encountered during drilling is presented on the boring logs. The water levels presented are for the times indicated. The water levels are approximate. Water levels can fluctuate several feet due to factors beyond the scope of this study.

Boring locations were determined by the drilling crew referencing existing site features unless denoted otherwise in the Geotechnical Report. Boring locations obtained by the drilling crew are approximate.

Ground surface elevations were determined by the drilling crew using a level survey referencing a temporary benchmark unless denoted otherwise in the Geotechnical Report. Elevations obtained by the drilling crew are approximate.

The subsurface soils presented on the boring logs are approximate. The exploratory boring logs represent general subsurface conditions based on visual observation of auger cuttings and periodic sampling. Additional drilling, sampling, Petrographic analysis and other testing may indicate other soil and bedrock types, and soil/bedrock layers may be present which could not be identified with this type of investigation.

The boring logs present sharp transitions between the various soil types. However, transitions usually occur more gradually in the field. The depths to the transitions are approximate.

The data presented on the boring logs is subject to the conclusions, recommendations and limitations discussed in the Geotechnical Report. Additional information on the subsurface soil, bedrock, groundwater and other conditions may be included in the report which are not presented on the boring logs.

Allied Laboratories
DEPT. OF PEC, PA
350 South Washington
Wichita, Kansas 67202

LABORATORY TEST SUMMARY

City of Wichita Land Use Study for Water Treatment Plant

74-15245-000-0147

BORING	SAMP. NO.	DEPTH (feet)	N Value	MOIST %	DRY DEN (pcf)	UCC (psf)	LL	PL	PI	%Gravel	%Sand	%Fines
B-1												
	B1-1	2.5	**4**									
	B1-2	5.0	**5**									
	B1-3	7.5	**10**									
	B1-4	10.0	**11**									
	B1-5	15.0	**2**									
	B1-6	20.0	**15**									
	B1-7	25.0	**13**									
	B1-8	30.0										
B-2												
	B2-1	5.0	**15**	16.9				NP	NP			
	B2-2	10.0	**30**	4.4						0	96	4
	B2-3	15.0	**24**									
	B2-4	20.0	**4**									
	B2-5	25.0	**15**									
	B5-6	30.0	**11**									
B-3												
	B3-1	5.0	**6**									
	B3-2	10.0	**12**	6.6						2	98	1
	B3-3	15.0	**10**									
	B3-4	20.0	**16**									
	B3-5	25.0	**13**									
	B3-6	30.0										
B-4												
	B4-1	2.5	**5**	1.9						0	99	1
	B4-2	5.0	**15**									
	B4-3	7.5	**12**	8.3						0	98	2
	B4-4	10.0	**14**									
	B4-5	15.0	**14**									
	B4-6	20.0	**7**									
	B4-7	25.0	**10**									
	B4-8	30.0	**9**									
PB-1	PB1-1	15.54										
PB-2	PB2-1	13.57										
PB-3	PB3-1	13.37										
PB-4	PB4-1	8.42										
PB-5	PB5-1	4.61										
PB-6	PB6-1	1.0										

Figure 15

ALLIED LABORATORIES
DEPT. OF PEC, P.A.
350 SOUTH WASHINGTON
WICHITA, KANSAS

SOIL CLASSIFICATION CHART

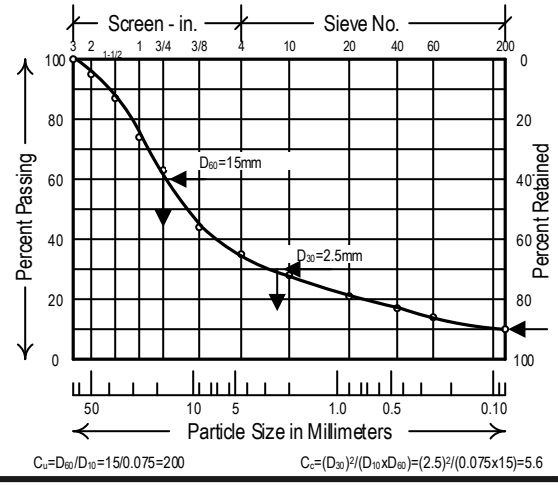
REFERENCE: ASTM D 2487
(Based on Unified Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50 % retained on No. 200 sieve.	**Gravels** More than 50 % coarse faction retained on No. 4 sieve.	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	**GW**	Well graded gravel [C, F]
			Cu < 4 and\or 1 > Cc > 3 [E]	**GP**	Poorly graded gravel [C, F]
		Gravels with fines More than 12% fines[C]	Fines Classify as ML or MH	**GM**	Silty gravel [F,G,H]
			Fines Classify as CL or CH	**GC**	Clayey gravel [F,G,H]
	Sands 50 % or more passes No. 4 sieve.	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	**SW**	Well graded sand [D, I]
			Cu < 6 and\or 1 > Cc > 3 [E]	**SP**	Poorly graded sand [D, I]
		Sands with Fines More than 12% fines[D]	Fines Classify as ML and MH	**SM**	Silty sand [G,H,I]
			Fines Classify as CL and CH	**SC**	Clayey sand [G,H,I]
Fine Grained Soils 50 % or more passes No. 200 sieve.	**Silts and Clays** Liquid Limit less than 50.	Inorganic	PI>7 and plots on or above "A" line [J]	**CL**	Lean clay [K,L,M]
			PI<4 and plots on or below "A" line [J]	**ML**	Silt [K,L,M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} \leq 0.75$	**OL**	Organic clay [K,L,M,N]
					Organic silt [K,L,M]
	Silts and Clays Liquid Limit of 50 or more.	Inorganic	PI plots on or above "A" Line	**CH**	Fat clay [K,L,M]
			PI plots below "A" Line	**MH**	Elastic silt [K,L,M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} \leq 0.75$	**OH**	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			**Pt**	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM Well graded gravel with silt.
GW-GC Well graded gravel with clay.
GP-GM Poorly graded gravel with silt.
GP-GC Poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols:
SW-SM Well graded sand with silt.
SW-SC Well graded sand with clay.
SP-SM Poorly graded sand with silt.
SP-SC Poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$; $Cc = (D_{30})^2 / (D_{10} \times D_{60})$.
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel" to group name.
[L] If soil contains ≥ 30% plus No. 200, predominately sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 4, predominately gravel, add "gravely" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

SIEVE ANALYSIS



$C_u = D_{60}/D_{10} = 15/0.075 = 200$ $C_c = (D_{30})^2/(D_{10} \times D_{60}) = (2.5)^2/(0.075 \times 15) = 5.6$

PLASTICITY CHART

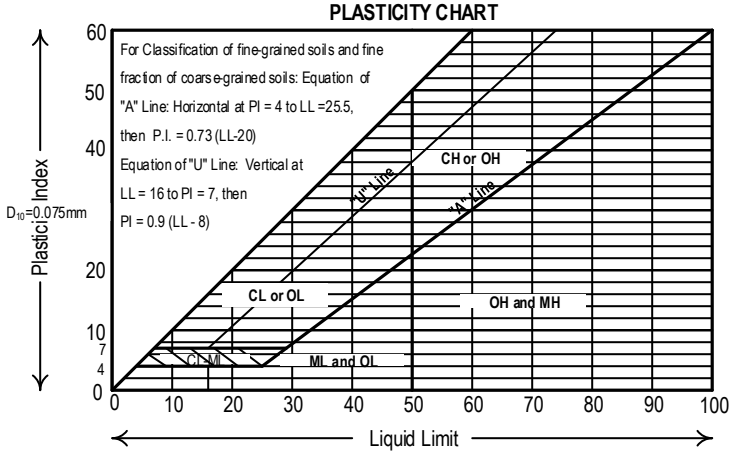


Figure 16

ALLIED LABORATORIES
DEPT. OF PEC, P.A.
350 SOUTH WASHINGTON
WICHITA, KANSAS

GENERAL GEOTECHNICAL NOTES

SOIL CLASSIFICATION TERMINOLOGY

Soil classification is based on ASTM D-2487 "Soil Classification for Engineering Purposes" which is based on the Unified Soil Classification System. Fine grained soils have less than 50 percent of their particles retained on the No. 200 sieve. These soils are classified as silts if they are non-plastic to slightly plastic and as clays if they classify as plastic. Coarse grained soils have more than 50 percent of their particles retained on the No. 200 sieve and are classified as sands, gravels, cobbles and boulders depending on the grain size. Minor and major constituents may be added as modifiers depending on the proportions of the soil types. Additionally, fine grained soils are described based on their consistency and coarse grained soils are delineated by their relative density. Examples: Fat clay with sand (CH) and Silty sand (SM).

WATER LEVEL MEASUREMENTS

Water level measurements presented on the test boring logs are for the times indicated. These measurements may not necessarily represent the actual groundwater levels at the site. Fine grained soils of low permeability may require measurements for extended periods to accurately reflect free water levels. Coarse grained soils will generally reflect true groundwater levels after short periods. Groundwater levels and seepage water can vary depending on time of year, climatic conditions and other factors beyond the scope of normal geotechnical explorations. Typical water level abbreviations follows:

WD - Water level during drilling
WA - Water level after drilling
W24 - Water level 24 hours after drilling
W48 - Water level 48 hours after drilling
CW - Depth to wet cave of boring
CD - Depth to dry cave of boring

SAMPLING AND DRILLING ABBREVIATIONS

Drilling and sampling procedures are typically performed in accordance with ASTM standards unless otherwise noted. Typical sampling and drilling abbreviations follows:

P - Standard Penetration sampler (1-3/8 in. ID split-spoon)
S - 3 in. diameter thin walled Shelby Tube
D - Denison Barrel Sampler
B - Bulk/grab sample
SB - Sawtooth bit barrel sampler
CF4 - 4 in. diameter continuous flight auger
CF6 - 6 in. diameter continuous flight auger
HS - 7-1/4 in. diameter hollow stem auger
NX - Diamond bit coring

DENSITY OF COARSE GRAINED SOILS

Relative Density (D_R)	Percent D_R	Approximate N - Value (blows/foot)
Very Loose	less than 15	0 to 4
Loose	15 to 35	4 to 10
Medium Dense	35 to 65	10 to 30
Dense	65 to 85	30 to 50
Very Dense	85 to 100	over 50

CONSISTENCY OF FINE GRAINED SOILS

Consistency	Unconfined Compressive Strength (Q_U) psf	Approximate N - Value (blows/foot)
Very Soft	Less than 500	0 to 2
Soft	500 to 1000	2 to 4
Medium Stiff	1000 to 2000	4 to 8
Stiff	2000 to 4000	8 to 16
Very Stiff	4000 to 8000	16 to 30
Hard	Over 8000	Over 30

BEDROCK HARDNESS DESCRIPTIONS

Hardness	Approximate N - Value (blows/foot)
Weathered (Soft)	Less than 20
Firm	20 to 30
Medium Hard	30 to 50
Hard	50 to 80
Very Hard	Over 80

PROPORTIONING OF CONSTITUENTS

Constituent Description	Percent
Trace	Less than 5
With	5 to 12
Modifier	More than 12

GRAIN SIZE DESCRIPTIONS

Constituent Description	Particle Size
Silt or Clay	Passing No. 200 Sieve (0.075 mm)
Sand	No. 200 to No. 4 Sieve (0.075 to 4.75 mm)
Gravel	No. 4 to 3 inch Sieve (4.75 to 75 mm)
Cobbles	3 to 12 inch Sieve (75 to 300 mm)
Boulders	Over 12 inch Sieve (300 mm)

Figure 17